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ABSTRACT

This paper highlights the results of analysis of achievement trends, described in report "Changes in Student Performance by Achievement Class and Model Class." This paper extrapolates from the complete study those findings that have the most direct implications for education policy and decision makers. Overall, students in the lowest performance quartiles realized greater gains than did those in the highest performance quartiles. In the lowest quartile, black students in the modal grades appropriate for 9-, 13- and 17-year-olds increased in reading and mathematics performance, and fourth graders in the highest quartile also increased in reading and mathematics. Moreover, black eighth graders in the highest quartile increased in reading performance, too. Often, gains by blacks in the modal grades exceeded those by whites in the modal grades. Both white and black 17-year-olds in the 11th grade who performed in the highest quartiles suffered substanial losses in mathematics and science. A section titled "Considerations for the Future" and a bibliography are included. Primary type of information provided by report: Results (Change) (Selective). (Author/PN)

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READING SCIENCE & MATHEMATICS TRENDS

A CLOSER LOOK

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Reading, Science and Mathematics Trends: A Closer Look

No. SY-RSM-50

by Barbara J. Holmes

and the Staff of the
National Assessment of Educational Progress

Education Commission of the States
Suite 700, 1860 Lincoln Street
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Foreword

When the U.S. Office of Education was chartered in 1867, one charge to its commissioners was to determine the nation's progress in education. The National Assessment of Educational Progress (NAEP) was initiated a century later to address, in a systematic way, that charge.

Since 1969, the National Assessment has gathered information about levels of educational achievement across the country and reported its findings to the nation. It has surveyed the attainments of 9-year-olds, 13-year-olds, 17-year-olds and adults in art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. All areas have been periodically reassessed in order to detect any important changes. To date, National Assessment has interviewed and tested more than 1,000,000 young Americans.

Learning-area assessments evolve from a consensus process. Each assessment is the product of several years of work by a great many educators, scholars and lay persons from all over the nation. Initially, these people design objectives for each subject area, proposing general goals they feel Americans should be achieving in the course of their education. After careful review, these objectives are given to writers, whose task it is to create exercises (items) appropriate to the objectives.

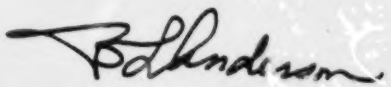
When the exercises have passed extensive reviews by subject-area specialists, measurement experts and lay persons, they are administered to probability samples. The people in these samples are selected in such a way that the results of their assessment can be generalized to an entire national population. That is, on the basis of the performance of about 2,500 9-year-olds on a given exercise, we can make generalizations about the probable performance of all 9-year-olds in the nation.

After assessment data have been collected, scored and analyzed, the National Assessment publishes reports and disseminates the results as widely as possible. Not all exercises are released for publication. Because NAEP will readminister some of the same exercises in the future to determine whether the performance levels of Americans have increased, remained stable or decreased, it is essential that they not be released in order to preserve the integrity of the study.

Acknowledgments

After 13 years of data collection, the National Assessment of Educational Progress has a wealth of information with myriad possibilities for analyzing trends in students' achievement. Such trends, juxtaposed with the findings of other research and shifts in education policy and practice, can provide education policy makers and practitioners with important insights into the implications of their actions. This report, which brings together data from reading, science and mathematics assessments and focuses on differences between the performance patterns of high and low achievers in light of events during the seventies, represents another step for the National Assessment in the direction of such reporting.

The abilities and advice of many people contributed to this report. Donald Searls, Kay Barrow and Edgar Ortiz designed and conducted the analyses; Valerie Daniels and Pamela Thayer provided technical assistance; and Arthur Wise, Gloria Gilmer, Frank Rapley and Ronald Anderson provided helpful insights during the review process. Thanks are also due to John Kalk for data processing support, Rexford Brown for editorial guidance and Marci Reser for production. The report was written by Barbara J. Holmes.



Beverly Anderson
Director

Highlights of the Findings

During the 1970s, the overall picture for reading performance was different than that observed for science and mathematics performance; generally, the reading performance of American youth improved for young students, while teenagers tended to hold their ground.

Mathematical performance changed during the 1970s, with losses observed for older students, while 9-year-olds performed at nearly the same level from one assessment period to the next. Science performance, however, stayed at about the same level for 9- and 13-year-olds, but 17-year-olds lost some ground.

When the performance of students in four quartiles of achievement is examined and analyzed by grade as well as by age, a somewhat sharper image emerges of where changes in performance occurred and of which groups of students realized performance gains and losses.

- Overall, students in the lowest performance quartiles realized greater gains than did those in the highest performance quartiles. Most of the gains were in reading, and for younger students, with some occurring, however, for 13-year-olds.
- In the lowest quartile, black students in the modal grades appropriate for 9-, 13- and 17-year-olds increased in reading and mathematics performance, and fourth graders in the highest quartile also increased in reading and mathematics. Moreover, black eighth graders in the highest quartile increased in reading performance, too. Often, gains by blacks in the modal grades exceeded that of gains by whites in the modal grades.
- Both white and black 17-year-olds in the 11th grade, who performed in the highest quartiles, suffered substantial losses in mathematics and science.

Introduction

During the 1970s, American education underwent a number of alterations, many in response to increased public concern over what students were, or were not, learning in school. One answer was to go "back to the basics." Another, favored by many states and local districts, was to give students minimum competency tests to identify those in need of remediation, or for grade promotion or high school graduation. At the same time, compensatory education programs flourished, as a result of continued federal commitments.

What, in fact, happened to education achievement during this period? And what are the implications for the future? To answer this question, the National Assessment of Educational Progress (NAEP) turned to data from its assessments of reading, science and mathematics. Previous reports have described overall trends in these areas during the seventies.[1] However, none has examined the combined implications of changes in these three areas — areas that are commonly accepted as critical to the development and maintenance of our increasingly technological society.

Additionally, past reports of achievement trends have focused on national averages. New secondary analyses reported herein investigate the trends for high achievers separately from those of low achievers. Past reports have also focused on students of a given age — 9-, 13- and 17-year-olds. This paper focuses upon students in particular grades, as well. Most 9-year-olds are enrolled in the 4th grade (i.e., the 4th grade is the modal grade for 9-year-olds), most 13-year-olds are in the 8th grade and most 17-year-olds are in the 11th grade. Examination of differences in performance for these modal grade youngsters can increase our understanding of the relationships between grade and performance and other factors. Such data can prove useful to those who make decisions about school entry dates, to teachers and to those who design and implement programs to help students achieve subject-area mastery.

This paper highlights the results of some of these analyses. A complete report of the study, including data tables and a description of the methodology and data base on which the analyses rest, is available from the Education Commission of the States (*Technical Report: Changes in Student Performance...*, 1982). This paper extrapolates from the complete study those findings that have the most direct implications for education policy and decision makers.

Some of the Factors Influencing Education in the Seventies

Through such programs as the Right-to-Read Effort, Title I of the Elementary and Secondary Education Act and other compensatory education programs, reading was the focus of great interest and many resources during the seventies, especially in elementary schools.

Conversely, science education was not particularly emphasized during the seventies, either in elementary or secondary schools. The public had been keenly aware of its importance during the early days of space exploration but that general awareness faded. Not only did federal funds for science become scarce during the

[1]Changes are reported in *Three National Assessments of Reading: Changes in Performance, 1970-80* (1981); *Changes in Mathematical Achievement, 1973-78* (1979); and *Three National Assessments of Science: Changes in Performance, 1969-77* (1978).

seventies, but states and local school districts, through their emphases and policies, tended to further contribute to an erosion of scientific interests and pursuits by students. Science fairs disappeared; budgets for science supplies and supplemental materials dwindled; and graduation requirements for science were eased. The number of students entering college with three years of secondary science education declined dramatically during the decade (*Science and Mathematics . . .*, 1982).

Although a part of Title I, mathematics generally suffered like science during the seventies. There was a decline in the number of qualified mathematics teachers at the secondary level and a corresponding decline in science and mathematics education enrollments at teacher training institutions. As senior teachers with many years of experience retired, it became difficult to replace them with equally well-qualified personnel. And many well-qualified personnel were lured by the real and perceived rewards of careers within business and industry — recognition, research opportunities and increased compensation.

At the same time, the public became seriously concerned with the quality of education. The public called for greater emphasis on basic skills such as grammar, punctuation, spelling, whole number computation, factual knowledge and literal comprehension — viewing them as the building blocks of student learning. With the rallying cry of "back to the basics," the public demanded — and in many instances, received — a redirection of curricular and instructional emphases. These were reinforced by the adoption of minimum competency testing measures in many states and local school districts.

General Changes in Performance in the Seventies

During the 1970s, 9-year-olds made significant gains in reading, while 13- and 17-year-old students performed at nearly the same levels in each assessment. In mathematics, 9-year-olds performed at nearly the same levels from one assessment to the next, but 13- and 17-year-olds lost ground. Only 17-year-olds declined in science; the others stayed at about the same level (*Three National Assessments of Reading*, 1981; *Changes in Mathematical Achievement*, 1979; *Three National Assessments of Science*, 1978).

Because assessments are designed to identify how defined groups of American students respond to assessment exercises, each national probability sample includes the major regions of the country, a cross-section of community types and sizes, various racial/ethnic groups and students of diverse family background. Principals of participating schools and students provide some of the data for these reporting categories.

A complete overview of group patterns relative to national levels of performance is available in the technical report from which these findings are extrapolated.

The remainder of this paper contrasts the performance patterns of white and black students because black youngsters comprised a major portion of the disadvantaged populations targeted for educational intervention during the 1970s.

Throughout the decade, black students, at each of the ages assessed by NAEP, performed below the national level, while their white counterparts performed above the national level. Although the position of these two groups did not change relative to national levels of performance, the *rate* of change for them in reading, science and mathematics was not the same. Table 1 compares mean changes in performance between white and black students.

TABLE 1. Mean Changes in Performance for 9-, 13- and 17-Year-Old White and Black Students in Reading, Science and Mathematics

	Age 9		Age 13		Age 17	
	White	Black	White	Black	White	Black
Reading	2.3*	5.1*	0.7	3.2*	−0.6	0.1
Science	-0.4	−0.4	−0.8	0.9	−1.9*	−2.8*
Mathematics	−2.6*	2.9*	−2.4*	0.6	−3.5*	−2.6*

*NAEP adheres to the standard convention whereby differences between statistics are designated as significant only if the differences are at least twice as large as their standard errors. Differences this large would occur by chance in 5% or fewer of all possible replications of the sampling, data collection and scoring procedures for any particular age population or reporting group. These differences are indicated, in the tables, with an asterisk (*).

Table 1 shows that black 9-year-olds made substantial gains in reading and in mathematics; conversely, white 9-year-olds experienced a decline in mathematics, and their gain in reading performance was not as large as that observed for their black counterparts. Also, black 13-year-olds gained in reading, while the performance of their white counterparts remained stable.

Gains in reading by 9- and 13-year-old black students had the positive effect of substantially closing the performance gap between themselves and students nationally. In mathematics, 13-year-old black youngsters remained stable while 13-year-old whites declined in performance. But both white and black 17-year-olds experienced substantial declines in mathematics performance.

A Closer Look at Changes in Performance: *Where* Were They?

It is against the backdrop of general education factors and performance trends just described that National Assessment reexamined the reading, science and mathematics results. Recognizing that important information about the rate of changes and ranges of students' performance can be obscured by relying solely on averages or mean measures, NAEP explored several analytic techniques to more clearly define students' performance during the seventies.[1]

In 1981, National Assessment designed the achievement-class variable as a means of gaining a broader context for reading performance during the seventies. The science and mathematics data have now been analyzed by the achievement-class variable and are reported here for the first time.

[1]The secondary analyses were performed on the data collected in the last two reading and science assessments so that performance in these two areas could be examined in the same general time frame as mathematics. Science data were collected in 1972-73 and 1976-77; mathematics, 1972-73 and 1977-78; reading, 1974-75 and 1979-80.

The Analysis of Students' Performance by Achievement Class

The achievement-class variable[2] partitions the NAEP sample into quartiles: low achievers, mid-low achievers, mid-high achievers and high achievers.

As a result of partitioning by quartiles, one can observe changes in the distribution[3] of a group of students across the quartiles and its performance within each quartile. Performance changes within an achievement class can be observed for uniformity. For example, given an average 3% change nationally, from one assessment to the next, one can observe whether there is a corresponding change within each of the achievement classes, or if the rate of change is higher or lower than that for the nation. This additional level of information provides a more comprehensive view of how much change has occurred and where it has occurred.

In addition, the results obtained by achievement classes make explicit the fact that each quartile of performance comprises students from all of the traditional reporting categories used by National Assessment. In other words, white and black students are in the lowest and highest achievement classes, as are students from all of the other categories such as regions of the country, community types and so on. Finally, the practical benefit of the analysis by achievement classes is that it allows an insight into what schools may be doing to help the lowest and the highest achieving students.

[2]Each student participating in a national assessment answers questions in a booklet of exercises (items). The achievement-class variable is created by placing each student in one of four achievement classes depending upon his or her performance on that booklet of exercises. This is, therefore, a post hoc analysis, the accuracy of which rests upon the extent to which students would tend to perform the same way on any of the exercise booklets used in any of the assessments.

[3]Results of the distributional analysis by achievement class for selected NAEP reporting groups are available in Chapter 2 of the technical report, *Technical Report: Changes in Student Performance* . . . (1982).

To ease the reader through the following discussion, the term "quartile" will be used interchangeably with "achievement class." Table 2 shows the national mean changes in performance in reading, science and mathematics, within the lowest and highest quartiles of performance.

A greater gain occurred in reading for 9-year-olds in the lowest quartile than for any other age population. Also, 9-year-olds in the highest quartile of reading performance gained, but not as much as students in the lowest quartile. Nine-year-olds in the lowest quartile of science and mathematics performance remained stable, but those in the highest quartile suffered fairly substantial losses in science (2.5%) and in mathematics (3%).

Also in reading, 13-year-olds in the lowest quartile gained (1.4%), while their peers in the highest quartile remained stable. Like 9-year-olds in the highest quartile, 13-year-olds in this quartile lost ground in science and mathematics.

Seventeen-year-olds in the lowest quartile demonstrated stability in reading, science and mathematics, but their peers in the highest quartile sustained large losses in science (3.9%) and in mathematics (4.3%).

Nationally, then, mathematics and science appear to be the learning areas in which students in the highest performance quartile declined during the seventies, whereas the performance of students in the lowest quartile remained stable in these areas.

The Analysis of Students' Performance by Modal Grade

In addition to the analyses of the reading, science and mathematics data by achievement class, data were examined for students in the modal grade. The modal grade is the grade in which the majority of students of a particular age are enrolled. The modal grade for 9-year-olds is 4th; for 13-year-olds, 8th; and for 17-year-olds, 11th. Presentation of the performance data in reading, science and mathematics by modal grade allows a comparison between changes for the entire age population nationally (which includes students above and below modal grade) and changes for just those students in the modal grade.

However, age data and modal grade data are of equal importance. National data for an entire age population include students who may be above or below modal grade for a variety of reasons. For example, school entry dates and retention policies vary across the nation. If only modal grade data were reported, the progress of a significant number of students could not be monitored.

Modal grade data are especially useful when juxtaposed with national level data for age populations and the reporting groups within

TABLE 2. National Mean Percentages of Changes in Performance in Reading, Science and Mathematics, Within Lowest and Highest Achievement Classes for 9-, 13- and 17-Year-Olds for Two Assessments

	Age 9		Age 13		Age 17	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Reading	5.0%*	1.4%*	1.4%*	0.3%	−1.0%	−0.4%
Science	1.0	−2.5*	1.5*	−2.5*	0.6	−3.9*
Mathematics	1.1	−3.0*	1.2	−3.4*	−1.2	−4.3*

*Asterisk indicates significant change in performance between assessments.

them. For example, age data indicate that certain groups of students (Hispanos, blacks, those who attend school in disadvantaged-urban communities and several others) tend to perform at levels below that of the nation in reading, science and mathematics. However, it is also the case that a disproportionate number of these students are found below modal grade. What are performance patterns for low performing groups in the modal grade?

Table 3 shows the national mean changes for students in the modal grades in reading, science and mathematics, within the lowest and highest achievement classes. In the lowest quartile, 9-year-olds in the 4th grade made significant gains in reading and in science, whereas 9-year-olds as a whole showed a gain in reading only. Eighth grade 13-year-olds in the lowest quartile also gained in reading and in science, but this was not different from the pattern for 13-year-olds as a whole. Like 17-year-olds as a whole, 11th graders in the lowest quartile showed no significant change in reading, science or mathematics.

In the highest quartile, 9-year-olds in their modal grade experienced a significant gain in reading, but declined significantly in science and mathematics. This pattern pertained also to 9-year-olds as a whole. Like the 13- and 17-year-old populations, students in the highest quartile and in their respective modal grades declined significantly in science and mathematics.

The similarity of the modal grade changes to the overall age changes tells us that the declines in the highest achievement class were not caused only by students below modal grade; nor were the increases for the low achievers caused only by improvements among students below modal grade. Both the improvements and the declines are also taking place within the modal grades.

Now, let's look at further changes in the lowest performance quartiles of reading, science and mathematics for the reporting categories and the groups within them. Exhibit 1 summarizes gains (+) and losses (−) in performance for white and black students, in the modal grades and in the lowest quartile for selected reporting groups. Exhibit 2 shows the same type of findings for students in the highest quartile.[4]

Exhibit 1 shows that for white 4th, 8th and 11th graders in the lowest quartile, the pattern of gains and losses shifted for certain groups of students. Readers should keep in mind the fact that the population groups are not discrete. A given student is in many groups at the same time, e.g., white, Northeast, male, disadvantaged-urban community type, and so forth. The reason for examining patterns across

[4]The percentages on which Exhibits 1 and 2 are based are in Appendix A in the technical report, *Technical Report: Changes in Student Performance* . . . (1982).

TABLE 3. National Mean Percentages of Changes in Performance in Reading, Science and Mathematics, Within Lowest and Highest Achievement Classes for 4th, 8th and 11th Graders

	Age 9 4th Graders		Age 13 8th Graders		Age 17 11th Graders	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Reading	6.1%*	1.4%*	1.7%*	0.4%	−0.1%	−0.5%
Science	1.4*	−2.4*	1.7*	−2.5*	0.4	−4.2*
Mathematics	0.4	−3.1*	1.1	−3.4*	−1.6	−4.3*

*Asterisk indicates significant change in performance between assessments.

EXHIBIT 1. A Summary of Gains and Losses in Modal Grade Performance in Reading, Science and Mathematics for White and Black 9-, 13- and 17-Year-Olds in Lowest Achievement Class for Selected Reporting Groups

	White									Black								
	Reading			Science			Mathematics			Reading			Science			Mathematics		
	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
Region																		
Northeast	+	=	-	+	=	=	+	=	-	+	+	+	=	=	-	+	=	+
Southeast	+	+	=	=	+	+	=	=	-	+	+	+	=	=	=	+	+	=
Central	+	=	-	=	=	=	=	=	=	+	+	-	-	-	=	+	=	-
West	+	+	=	=	+	=	=	=	-	+	+	=	+	=	=	+	=	=
Sex																		
Male	+	=	-	=	+	=	=	=	=	+	+	+	-	=	=	+	+	=
Female	+	=	=	+	=	=	=	=	-	+	+	=	=	+	=	+	+	+
Title I																		
Yes	+	=	-	+	+	=	=	=	=	+	+	+	=	+	=	+	+	+
No	+	=	-	=	+	=	=	=	-	+	+	=	+	=	=	+	+	=
Type of community																		
Rural	+	=	=	+	+	-	-	-	=	+	=	+	+	=	+	+	=	-
Disadvantaged urban	+	+	-	=	=	=	+	=	-	+	+	=	=	+	=	+	=	+
Advantaged urban	+	=	=	+	+	=	+	=	=	+	-	=	=	+	+	+	Undefined	=
Size of community																		
Big cities	+	+	=	=	=	+	-	=	=	+	+	=	=	+	=	+	=	+
Fringes around big cities	+	+	=	+	+	=	=	=	-	+	=	=	=	+	+	+	+	=
Medium cities	+	=	=	+	+	=	+	+	-	+	+	+	=	=	-	+	+	+
Smaller places	+	=	-	+	+	=	=	=	=	+	+	=	-	=	=	+	=	=
Percent white enrollment																		
0-59% white school	+	=	-	+	=	+	=	=	-	+	+	=	=	=	=	+	+	+
60-100% white school	+	=	-	=	+	=	=	=	-	+	+	+	=	+	=	+	=	+
Parental education																		
Not graduated high school	+	=	-	=	+	+	=	=	-	+	+	=	-	+	-	+	+	=
Graduated high school	+	=	-	+	+	=	=	=	-	+	=	=	=	=	=	+	+	+
Post high school	+	=	-	=	=	=	=	=	-	+	+	=	=	=	+	+	+	+
Reading resources																		
< 3 categories	+	+	=	+	+	=	=	=	=	+	+	=	=	=	-	+	+	+
3 categories	+	=	=	=	+	=	=	=	=	+	=	+	-	=	=	+	=	+
4 categories	+	=	-	+	+	=	=	=	-	+	+	+	=	+	+	+	=	+

Legend
+ = significant gain
- = significant loss
= = no significant change

groups is to see how pervasive a change has been socially — that is, how many different kinds of students and schools contributed to the achievement ups and downs.

Reading

- More of the white population groups showed gains in reading than in science or in mathematics, and most of these gains were among groups of fourth graders.
- Eighth graders, too, had some gains in reading: for example, students in the Southeastern and Western regions gained and so did those who attend school in disadvantaged-urban schools.
- Some losses occurred among the groups of 11th graders: for example, among males and for students in the Northeastern and Central regions of the country.

Science

- Overall, white students in their modal grades demonstrated a lot of stability and more gains than losses in science at each age. Stability was particularly evident among the 11th graders, and the gains occurred for 4th graders.
- The only loss for white students in the modal grade and in the lowest quartile of performance occurred for 11th graders who attend school in rural communities.

Mathematics

- Gains in performance occurred for white fourth graders in the Northeast, those who attend schools in both disadvantaged- and advantaged-urban communities and for those who live in medium-sized cities. Among this latter group, gains were also observed for the eighth graders.
- More losses in mathematical performance occurred for whites in the 11th grade than for the younger students intheir respective modal grades. For example, 11th graders in the Northeastern, Southeastern and Western regions of the country experienced a loss, with only those in the Central region showing stability. Females in the 11th grade and those who attend school in disadvantaged-urban communities also experienced a loss in mathematical performance.

By contrast, Exhibit 1 indicates the following pattern of gains and losses for groups of black students, also at ages 9, 13 and 17 and in the modal grades.

Reading

- All of the black population groups gained at the fourth-grade level, and most groups gained in reading also at the eighth-grade level. Only black eighth graders who attend school in advantaged-urban communities experienced a decline in reading performance.
- Gains occurred also for certain groups of black students in the 11th grade; for example, students in the Northeast and Southeast and males and students who attend schools in rural communities.
- Only one group of 11th graders experienced a decline: those in the Central region.

Science

- Overall, the science performance of black students at each age and in their modal grades was characterized by more stability and gain than by losses. This pattern held for most of the reporting categories.
- As a whole, more groups of 8th graders gained more than 4th or 11th graders. For example, 13-year-old females, students who attend school in advantaged- and disadvantaged-urban communities and students who reside in the Northeast and the Southeast gained in science performance.

- Seventeen-year-olds in the 11th grade in the Northeast lost ground in science, as did those who live in medium-sized cities.

- Fourth and eighth graders in the Central region also lost ground in science.

Mathematics

- Overall, more gain and stability than loss was observed in mathematical performance at each age for black youngsters in the modal grades.

- Only 11th graders in the Central region and those who attend school in rural communities lost in mathematical performance.

- All remaining groups, at each age, either made a positive change or demonstrated stability in performance.

Corresponding to Exhibit 1 (but for the highest quartile), Exhibit 2 indicates a difference between the performance patterns of white and black 4th, 8th and 11th graders. Here is an overview of patterns in reading, science and mathematics for white students in the highest quartile.

Reading

- As was the case with white students in the lowest quartile, reading performance of white students in the highest quartile fared better than did science or mathematical performance.

- Overall, there were few changes in reading performance — especially among the teenagers in the 8th and 11th grades. Most changes occurred for 4th graders and these changes were positive. For example, gains were observed for students in the Southeast, for males, for students in advantaged-urban community schools and several other categories as well.

- No losses occurred in the reading performance of the highest quartile for any age population.

Science

- Overall, the science performance of white students was marked by losses at each age in the highest quartile, across the majority of reporting categories.

- One exception to the overall pattern of loss was observed among fourth graders who attend Title I eligible schools: this group gained in science performance.

Mathematics

- Overall, mathematical performance was marked by more losses than science. This pattern pertained across the three age populations of white students and across the majority of reporting categories.

- The only gain realized in mathematics was for fourth graders whose parents have not graduated from high school.

- Only two groups — fourth graders who attend school in disadvantaged-urban communities and eighth graders in the Southeast — remained stable.

- All other groups, at each age, showed losses in mathematical performance.

By contrast, Exhibit 2 shows the following patterns of gains and losses for groups of black students, also at ages 9, 13 and 17 and in the modal grades.

Reading

- Most groups of black 4th and 8th graders made gains in reading performance. Among black 11th graders, performance for various groups either remained the same or declined.

Science

- Several groups of black fourth graders experienced gains in science performance: for example, students in the Northeast, those

EXHIBIT 2. A Summary of Gains and Losses in Modal Grade Performance in Reading, Science and Mathematics for White and Black 9-, 13- and 17-Year-Olds in Highest Achievement Class for Selected Reporting Groups

	White									Black								
	Reading			Science			Mathematics			Reading			Science			Mathematics		
	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
Region																		
Northeast	=	=	=	-	-	-	-	-	-	+	+	-	+	=	-	+	=	-
Southeast	+	=	=	-	-	-	-	=	-	+	+	-	=	-	=	+	-	-
Central	=	=	=	-	-	-	-	-	-	+	=	=	=	-	-	+	-	-
West	+	=	=	-	-	-	-	-	-	+	+	-	=	-	-	+	=	-
Sex																		
Male	+	=	=	-	-	-	-	-	-	+	+	=	=	=	-	+	-	-
Female	=	=	=	-	-	-	-	-	-	+	+	-	=	-	-	+	-	-
Title I																		
Yes	=	=	=	+	-	-	-	-	-	+	+	=	=	-	-	+	-	-
No	+	=	=	-	-	-	-	-	-	+	+	-	=	=	-	+	-	-
Type of community																		
Rural	=	=	=	-	-	-	-	-	-	+	+	-	=	-	=	=	+	=
Disadvantaged urban	=	+	=	-	-	=	=	-	-	+	+	=	+	-	-	+	-	-
Advantaged urban	+	=	=	-	-	-	-	-	-	=	=	-	+	+	-	=	=	=
Size of community																		
Big cities	+	=	=	-	-	-	-	-	-	+	+	-	=	=	-	+	-	-
Fringes around big cities	=	=	=	-	-	-	-	-	-	+	+	=	+	=	=	+	+	-
Medium cities	=	=	=	-	=	-	-	-	-	+	=	-	+	-	-	+	-	=
Smaller places	=	=	=	-	-	-	-	-	-	+	+	-	=	=	-	+	-	-
Percent white enrollment																		
0-59% white school	=	=	=	-	=	-	-	-	-	+	+	=	+	-	-	+	-	-
60-100% white school	+	=	=	-	-	-	-	-	-	+	+	-	=	=	-	+	-	-
Parental education																		
Not graduated high school	=	+	=	=	-	=	+	-	-	=	+	=	-	=	-	+	-	-
Graduated high school	+	=	=	-	-	-	-	-	-	+	+	-	=	-	-	+	-	-
Post high school	=	=	=	-	-	-	-	-	-	+	+	-	=	=	-	+	-	-
Reading resources																		
<3 categories	=	=	=	-	-	-	-	-	-	+	=	=	=	-	-	+	-	-
3 categories	+	=	=	-	-	-	-	-	-	+	+	=	=	-	-	+	-	-
4 categories	=	=	=	-	-	-	-	-	-	+	+	-	+	=	-	+	=	=

Legend
+ = significant gain
- = significant loss
= = no significant change

who attend school in disadvantaged- and advantaged-urban communities, those who live in fringes around big cities and in medium-sized cities.

- Most groups of black eighth graders declined or remained stable in science performance. However, those who attend school in advantaged-urban communities gained in performance.

- Losses in science performance were concentrated among various groups of blacks at age 17 and in the 11th grade.

- A concentration of losses in science performance occurred at age 17, among the 11th graders, rather than among the younger students in the 4th and 8th grades. However, the performance of four groups of 17-year-old blacks remained stable; students in the Southeast, those who attend school in rural communities and those who live in fringes around big cities and in medium-sized cities.

Mathematics

- Overall, the pattern for mathematics is similar to that of science: gains for the younger black students, with losses concentrated among the 11th graders, but some stability also observed for the 8th and 11th graders.

- The majority of groups in the fourth grade made gains in mathematical performance, with only two — students who attend school in rural and in advantaged-urban communities — showing no change. At a risk of redundancy, no group of black fourth graders experienced a decline in mathematical performance.

- In the eighth grade, while the majority of groups experienced a decline, two groups gained: these were students who attend school in rural communities and those who live in fringes around big cities.

- In the 11th grade, while the majority of groups experienced a decline, students who attend school in rural communities and in advantaged-urban communities, those who live in medium cities and who report having four categories of reading resources in their homes remained stable in mathematics performance.

In summary, Exhibits 1 and 2 indicate that more performance *losses* occurred in mathematics than in science or in reading for students in the lowest *and* highest achievement classes, whether white or black. Conversely, more performance *gains* occurred in reading than in mathematics or in science for students in the lowest and highest achievement classes, whether white or black. Additionally, more gains occurred for students in the *lowest quartile of performance*, whether white or black, regardless of learning area. Finally, the performance of black youngsters in the 4th and 8th grades at ages 9 and 13 tended to increase or to remain stable, while the performance of their white counterparts either declined or remained stable in all three learning areas. Both white and black high achievers in the 11th grade suffered substantial losses in mathematics and science.

Exhibit 3 graphically displays an overview of the findings just described and allows us to see the general direction of performance changes for white and black students, in the lowest and highest quartiles, in 4th, 8th and 11th grades. Supporting figures for Exhibit 3 appear in Table 4.

EXHIBIT 3. Changes in Lowest and Highest Achievement Classes in Reading, Science and Mathematics for White and Black Students in Modal Grades

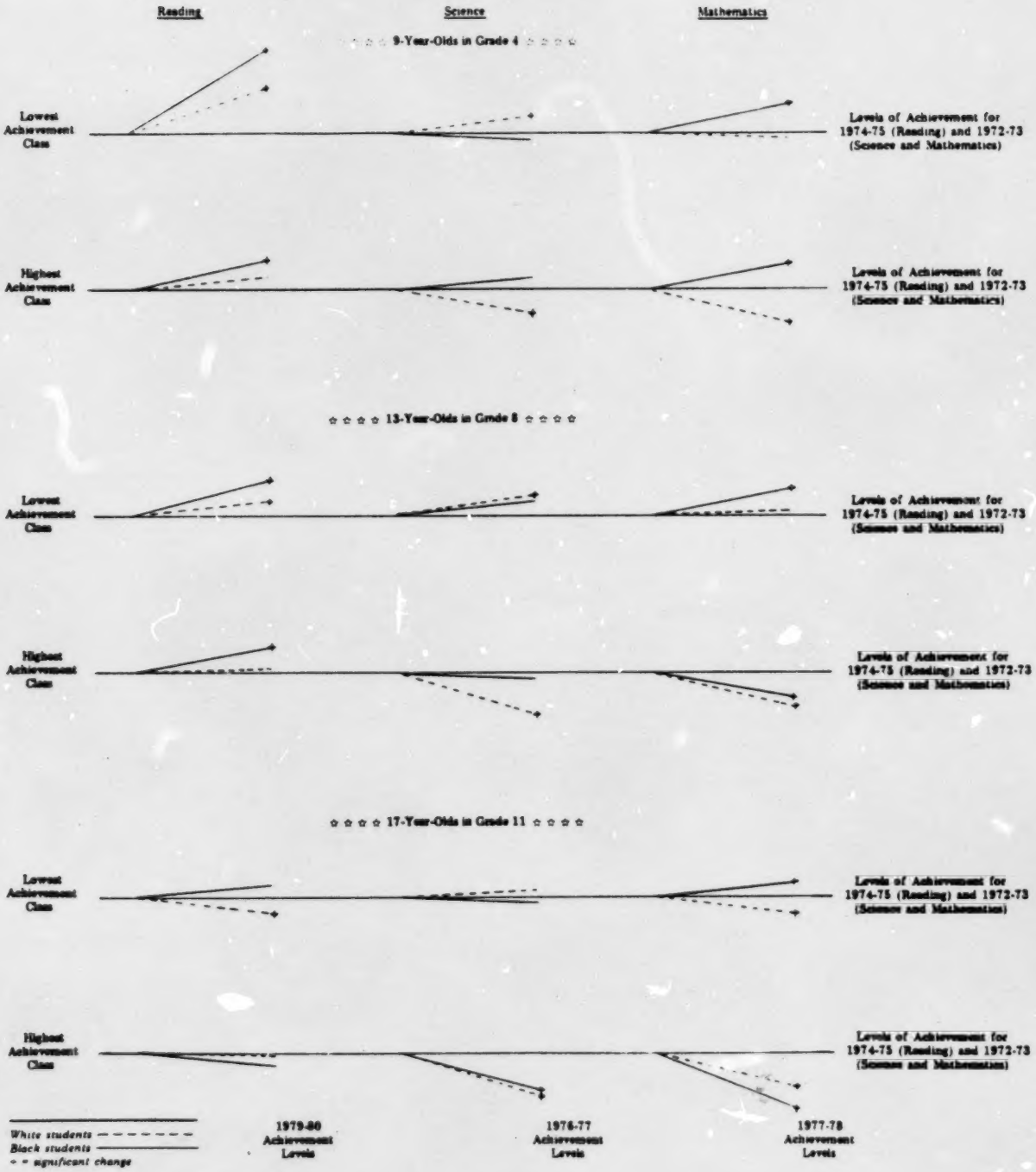

Reading
Science
Mathematics
9-Year-Olds in Grade 4
Lowest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
Highest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
13-Year-Olds in Grade 8
Lowest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
Highest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
17-Year-Olds in Grade 11
Lowest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
Highest Achievement Class
Levels of Achievement for 1974-75 (Reading) and 1972-73 (Science and Mathematics)
White students
Black students
☆ = significant change
1969-80 Achievement Levels
1976-77 Achievement Levels
1977-78 Achievement Levels

TABLE 4. Mean Percentage Changes Between Two Assessments in Lowest and Highest Achievement Classes in Reading, Science and Mathematics for White and Black Students in Modal Grades

	Black			White		
	Reading	Science	Mathematics	Reading	Science	Mathematics
			Lowest Achievement Class			
9-year-olds	8.4*	−0.7	2.9*	4.6*	1.7*	−0.5
13-year-olds	3.5*	1.3	2.6*	1.5*	2.0*	0.3
17-year-olds	1.1	−0.5	1.6*	−1.7*	0.7	−1.8*
			Highest Achievement Class			
9-year-olds	3.0*	1.1	2.6*	1.2	−2.4*	−3.3*
13-year-olds	2.5*	−0.5	−2.5*	0.4	−4.1*	−3.2*
17-year-olds	−1.1	−3.9*	−5.5*	−0.3	−4.2*	−4.3*

*Asterisk indicates significant change in performance between assessments.

Considerations for the Future

To gain a cross-sectional view of education policy direction and options for the eighties, National Assessment invited several persons to participate in a conference with staff to consider the implications of the findings described in this paper. Participating were Ronald Anderson, Gloria Gilmer, Frank Rapley and Arthur Wise.[1] Their opinions are theirs alone and do not necessarily represent either the view of the institutions with which they are affiliated or those of the National Assessment of Educational Progress, the Education Commission of the States or the National Institute of Education.

A synthesis of the conference discussion is presented below as a series of "considerations" for different kinds of policy makers and those who implement education policies.

Considerations for Public Educators — State Boards of Education, Teacher Training Institutions

Although reading achievement increased for most American students during the seventies, achievement levels in science and mathematics remained stable or declined. At the same time that demand for competent people in technological areas is growing, the number of qualified science and mathematics teachers in preparation at teacher training institutions (Howe and Gerlovich, 1982) has dropped and the number of high school graduates equipped for highly technical fields has gone down as well (*State-Mandated Graduation Requirements 1980*, 1980). In light of these trends, perhaps educators should consider:

- Reviewing the relationship between teacher training and technical fields curricula and the programs of secondary schools. Often students complete high school without the appropriate sequence and/or number of science and mathematics courses needed to pursue careers in technical fields or as teachers.

- Reviewing teacher training and teacher certification policy, especially for the elementary level. Often elementary school teachers have had little or no training in science and mathematics, although they are certified to teach at the elementary level.

Considerations for Teachers, Interventionists, Curriculum Developers and Specialists

Data collected by the National Assessment (*Technical Report: Changes in Student Performance . . .*, 1982, Table 10) indicate that more black 9-year-olds were retained in grade during the mid-to-late seventies than in the assessment years prior to that time. By 1980, 34% of the

[1]Dr. Ronald Anderson, professor of Science Education, School of Education, University of Colorado; Dr. Gloria Gilmer, co-chair, Panel on Remediation, Mathematical Association of America; Dr. Frank Rapley, superintendent of schools, Kalamazoo, Michigan; Dr. Arthur Wise, senior social scientist, Rand Corporation.

9-year-olds blacks were below modal grade compared with 27% of the white 9-year-olds. Although the proportions of black 13- and 17-year-olds below modal grade did not increase, at age 13, 36% were below modal grade compared with 28% of the white students, and at age 17, 29% of the black students were below modal grade compared with 11% of the white students.

Results presented in this paper clearly suggest that black students in the modal grades appropriate to their ages increased significantly in performance during the seventies. In the lowest quartile, all three ages increased in reading and mathematics performance, and fourth graders in the highest quartile also increased in reading and mathematics. Moreover, black eighth graders in the highest quartile increased in reading, too. Often the gains by blacks in the modal grade exceeded that of gains by whites in the modal grades. (See Appendix A in the technical report.) In light of these performance patterns, educators may want to reconsider:

- Retention policies that separate students from the age/grade group when remediation is indicated. Successful intervention programs, such as Project SEED (Special Elementary Education for the Disadvantaged) teach the entire class at the same time and at the same pace, in a very supportive environment.

Evidence from this study and other reports published by the National Assessment during the seventies suggests that student gains were concentrated around the fundamental, low order skills. Conversely, some losses were observed in inferential comprehension in reading (*Three National Assessments of Reading . . .*, 1981), in problem solving in mathematics (*Changes in Mathematical Achievement . . .*, 1979) and in the physical sciences (*Three National Assessments of Science . . .*, 1978). These findings suggest that educators reconsider certain assumptions about how children learn.

- Children can and do learn large chunks of very difficult material very early. Lower order, so-called basic skills, are not necessarily the "building blocks" essential to acquiring higher order, cognitive skills such as problem solving, analyzing and synthesizing. Neither are the teaching strategies associated with the acquisition of lower order skills the same as those required to inculcate higher order skills. Learning is not the linear process popularly perceived by the public.[2] As pointed out in a recent report by the National Council of Teachers of Mathematics,

> . . . problem solving [should] not be deferred until computational skills are mastered. Problem solving and learning of more advanced skills reinforce the learning of computational skills and provide meaning for their application (*Results From the Second Mathematics Assessment . . .*, 1981, p. 148).

Teachers should be encouraged to:

- Rely on their intuitive responses to students; students do best when teacher expectations are high for all students.
- Vary pedagogies; many of the successful science and mathematics intervention programs incorporate "questioning/discovery" strategies to aid in developing conceptual skills.[3]
- Allow students to experiment by changing roles, allowing students to lead discussions and to plan lines of inquiry.
- Change the pace of curricular coverage, when indicated, and include an interdisciplinary approach to content. Application of reading to mathematics and science will stimulate learning in all three areas. Rigid adherence to the scope and sequence of a lesson plan or textbook tends to stifle teachers' creativity.

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[2]For an overview of selected neuroscientific research with educational implications, see *Education and the Brain* (1978).

[3]For example, Project SEED (Special Elementary Education for the Disadvantaged); MESA (Mathematics, Engineering, Science Achievement Program); North Carolina School of Science and Mathematics; Houston's High School for Engineering Profession.

- Reduce reliance on test results. The strong emphasis on testing during the seventies has produced a cued-recall type of teaching and overdependence on a lock-step progression through the content material.

- Teach the same material to all students, varying the level to recognize different student abilities.

This closer look at achievement patterns suggests that many positive things were going on in the schools during the seventies. Disadvantaged youngsters and low achieving students made considerable gains, especially in reading and especially in elementary school. But these findings point to short-comings as well: they clearly indicate that we did not do as good a job in science or mathematics as in reading, nor did we help high achieving students continue to demonstrate the potential they showed in elementary school. The challenge now is to give attention to science and mathematics, while not losing ground in reading, and to find ways to strengthen students in the higher order skills. Only by attending to these issues will we bring the schools back into synch with the economic and social needs of the 1980s and 1990s.

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